

Wind Water Nexus

Larry Flowers, NREL

- Water Supply & Quality- often as important as electric supply
- Irrigation & Thermal Electric Generation accounts for approximately 77% of US fresh water use
- Population/Urban Growth & Climate impact- increasing stress on water supplies

Total Water Withdrawals, 2000

Public supply, 11 percent



Public supply water intake, Bay County, Florida

Richard L. Marella, USGS

Irrigation, 34 percent



Gated-pipe flood irrigation, Fremont County, Wyoming

Jeff Vanuga, USDA NRCS

Aquaculture, less than 1 percent



World's largest trout farm, Buhl, Idaho

Courtesy of Clear Springs Foods, Inc.

Mining, less than 1 percent



Spodumene pegmatite mine, Kings Mountain, North Carolina

Nancy L. Barber, USGS

Domestic, less than 1 percent



Domestic well, Early County, Georgia

Alan M. Cressler, USGS

Livestock, less than 1 percent



Livestock watering, Rio Arriba County, New Mexico

Jeff Vanuga, USDA NRCS

Industrial, 5 percent



Paper mill, Savannah, Georgia

Alan M. Cressler, USGS

Thermoelectric power, 48 percent

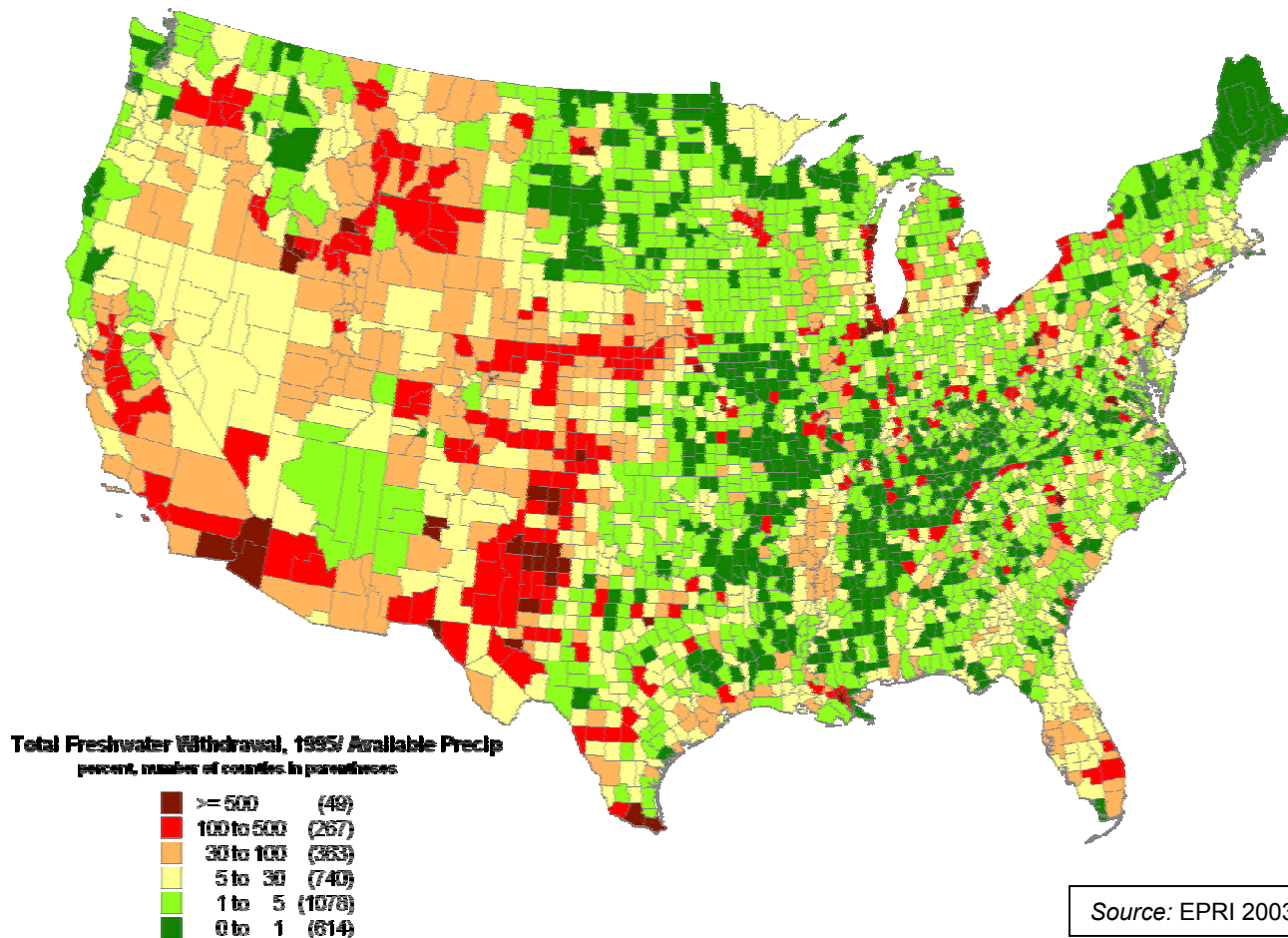


Cooling towers, Burke County, Georgia

Alan M. Cressler, USGS

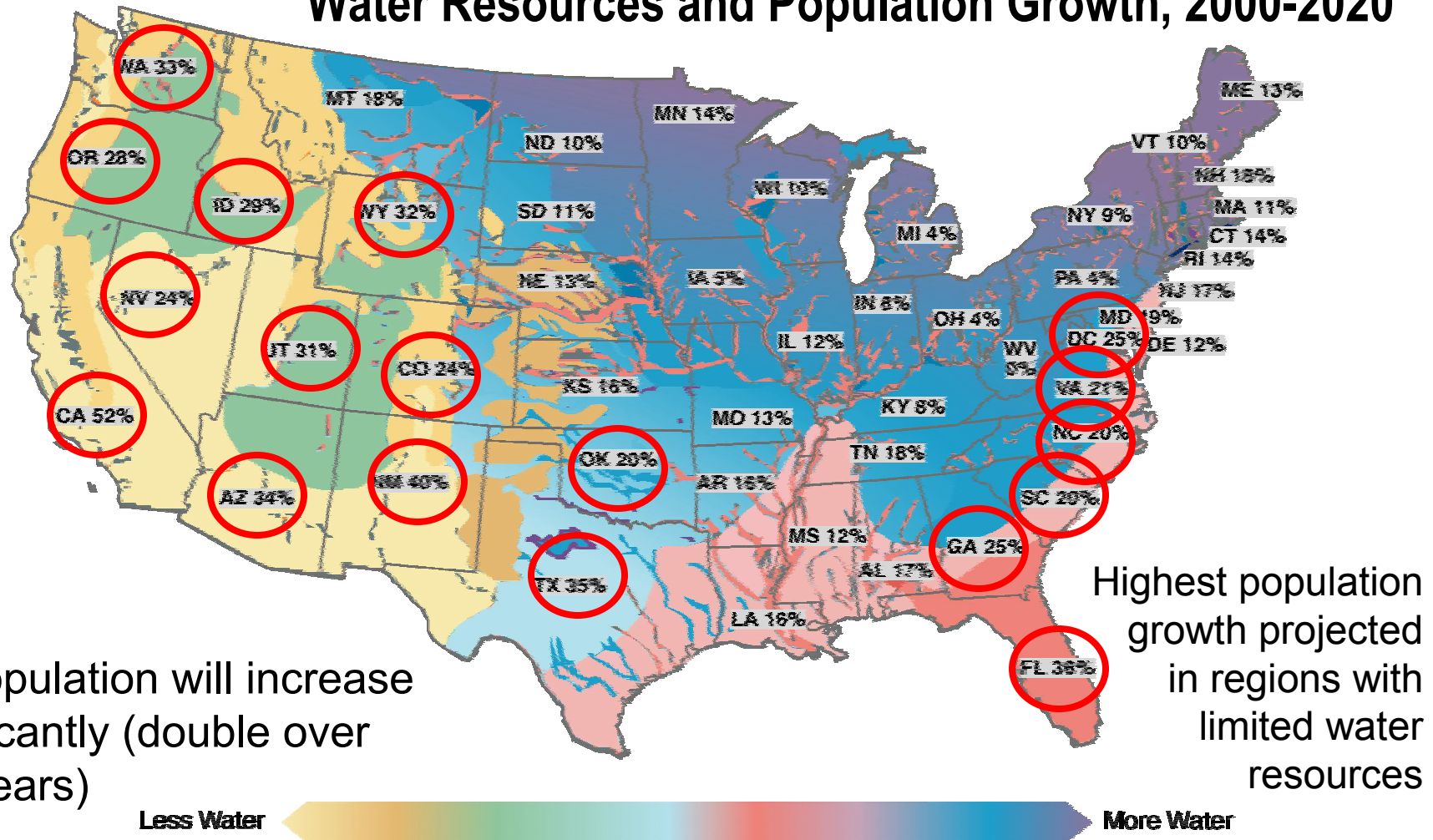
Source: USGS Circular 1268, 15 figures, 14 tables (released March 2004 and revised April and May 2004). Available at: <http://water.usgs.gov/pubs/circ/2004/circ1268/index.html>

Sustainable Withdrawal Of Freshwater Is National Issue



Conflicts between economic development and water availability will continue across the US

Water Resources and Population Growth, 2000-2020



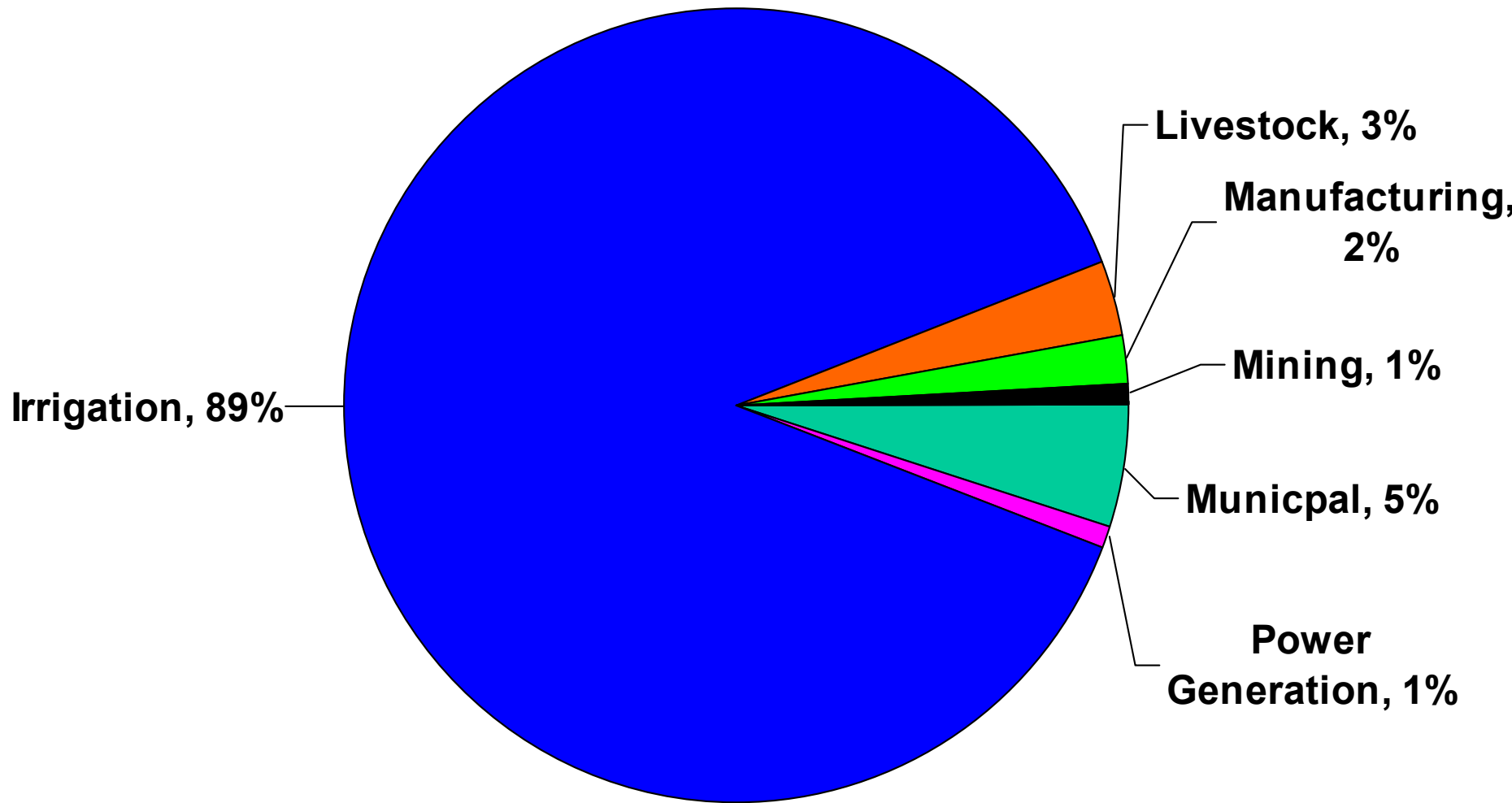
Source: DOE/NETL (M. Chan, July 2002)

A large center pivot irrigation system is shown over a lush green field. The system consists of a long metal structure with multiple wheels and a central pivot point, supported by a series of vertical risers. Water is being distributed from the structure into the field. The sky is blue with scattered white clouds. In the background, there are some industrial structures and power lines.

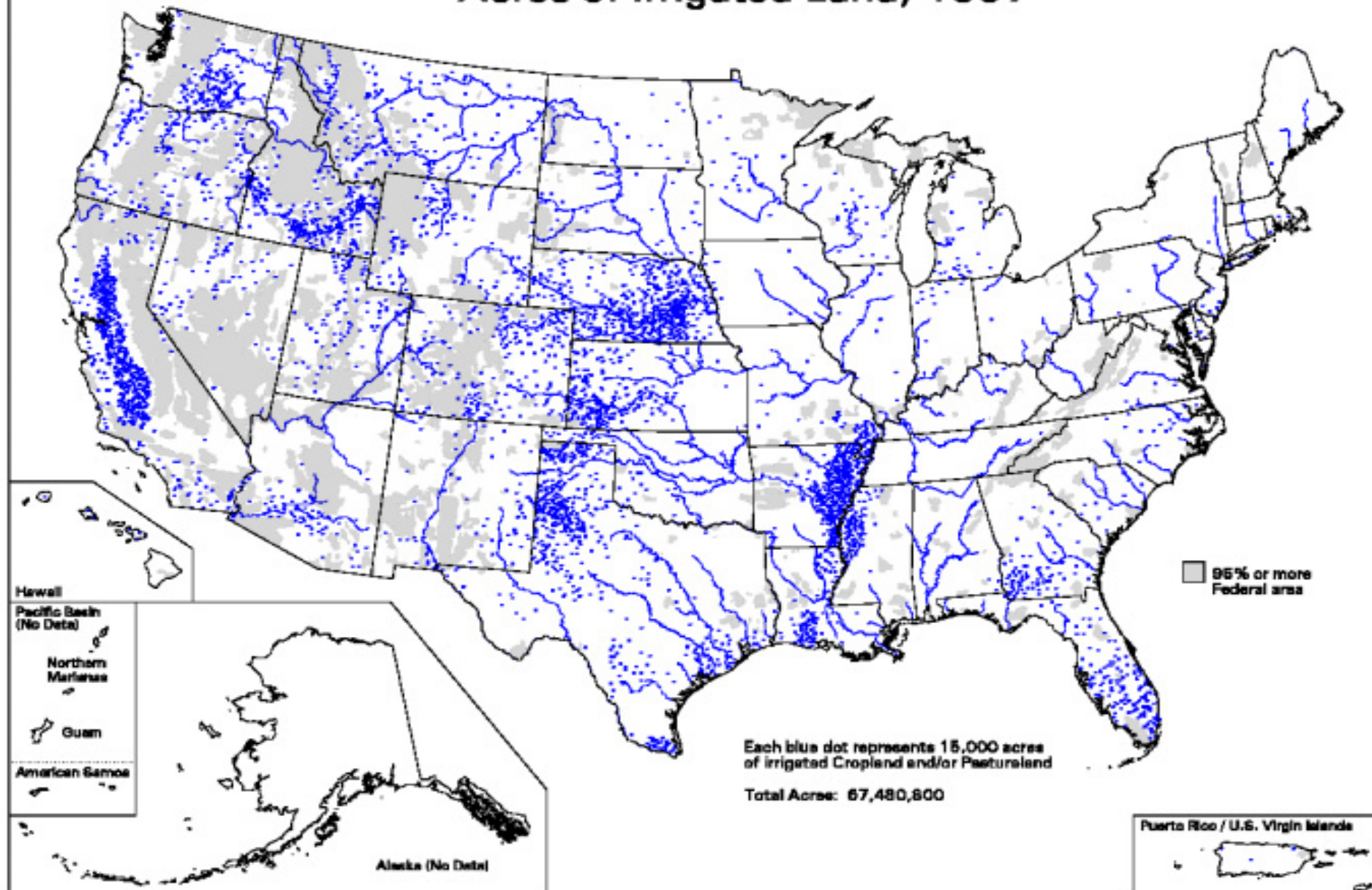
Irrigation

R. Nolan Clark
USDA-Agricultural Research Service
Bushland, TX

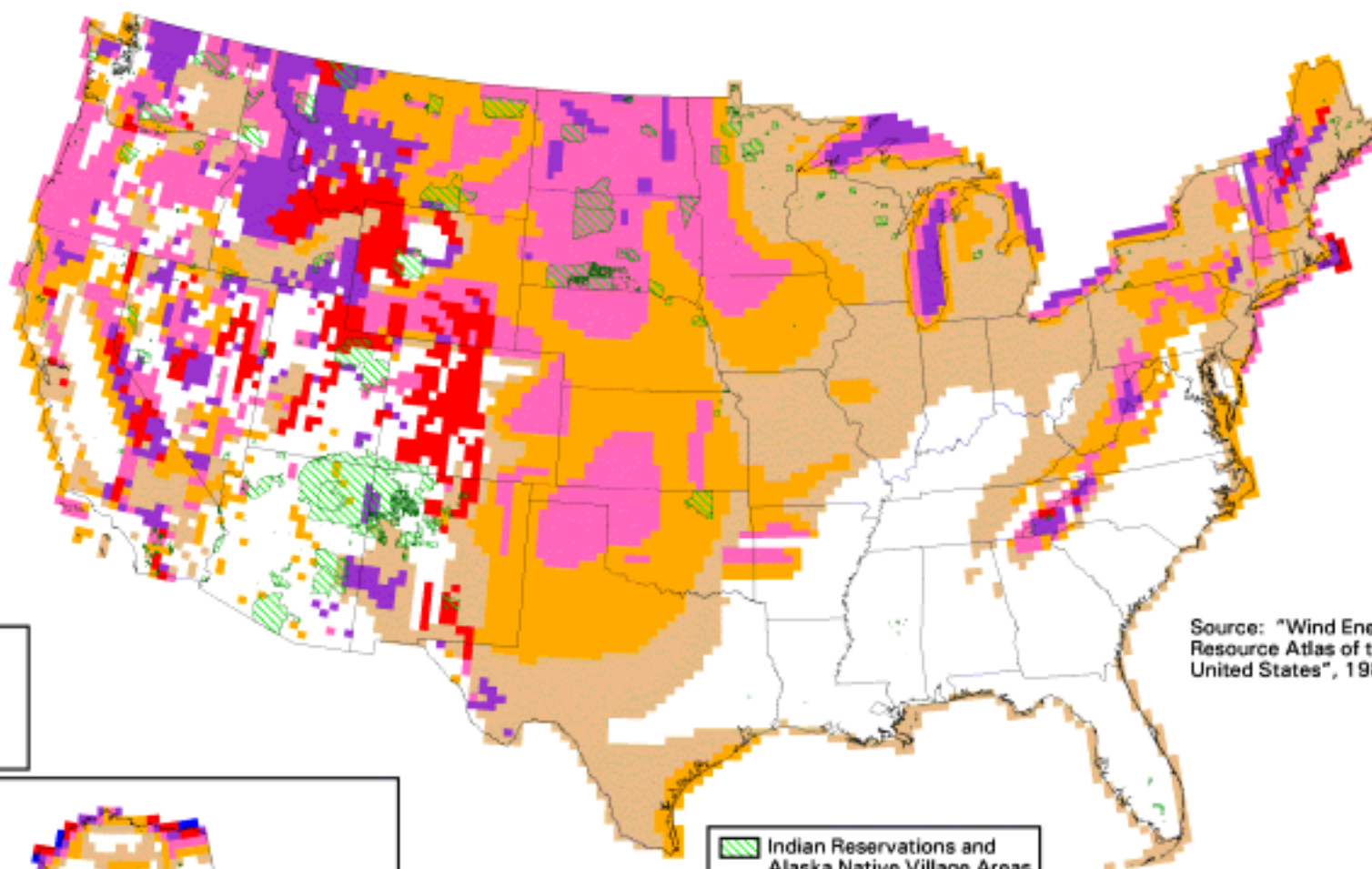
Water Use for 2000



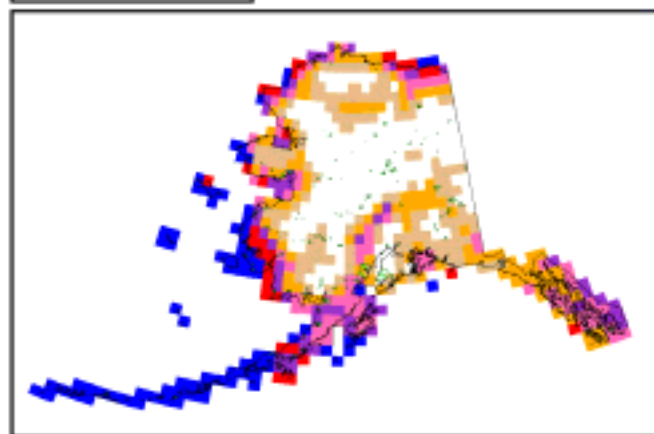
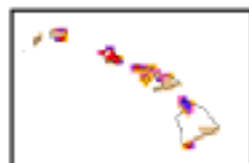
Acres of Irrigated Land, 1997



United States - Wind Resource Map



Source: "Wind Energy Resource Atlas of the United States", 1987



Wind Power Classification

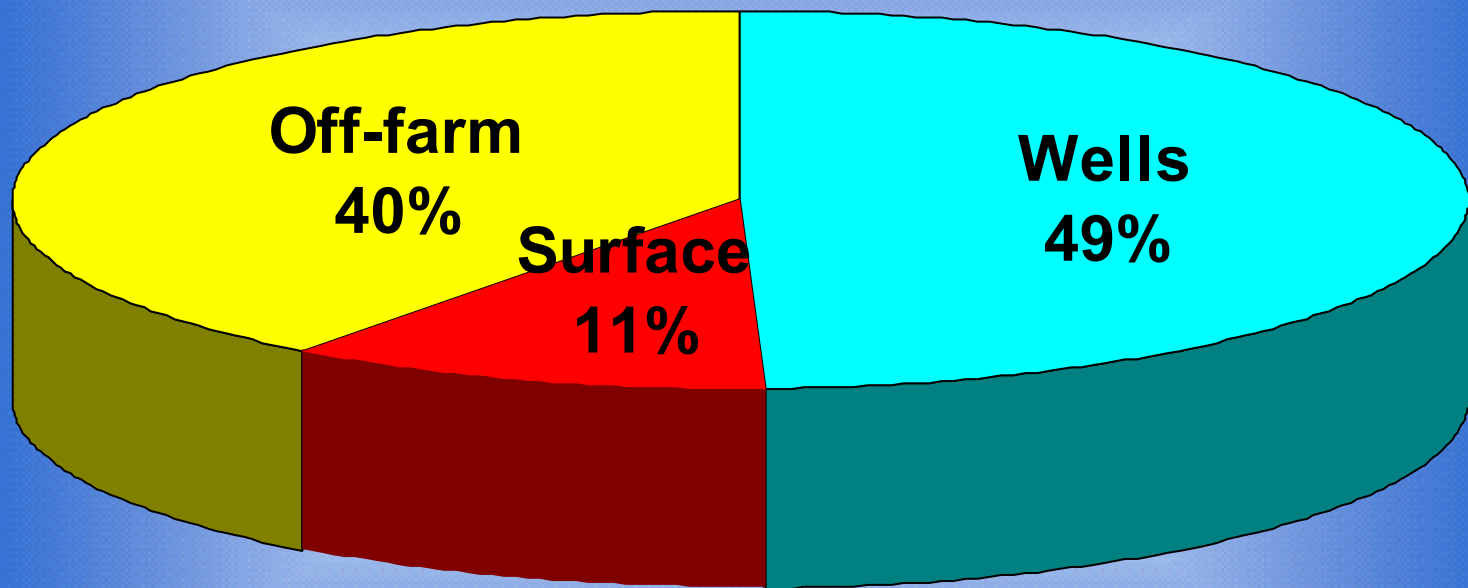
Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m ²	Wind Speed ^a at 50 m m/s	Wind Speed ^a at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

^a Wind speeds are based on a Weibull k value of 2.0

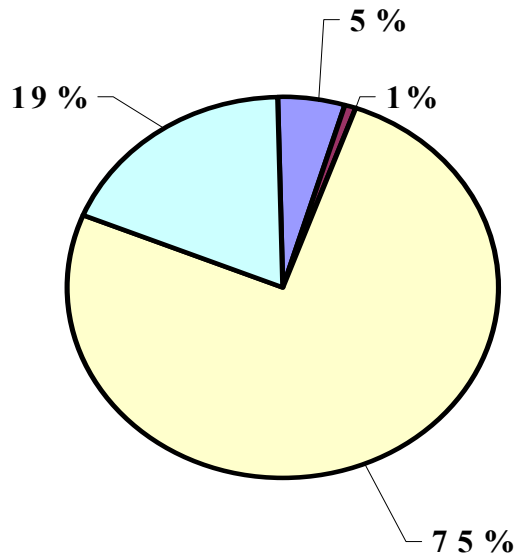
U.S. Department of Energy
National Renewable Energy Laboratory



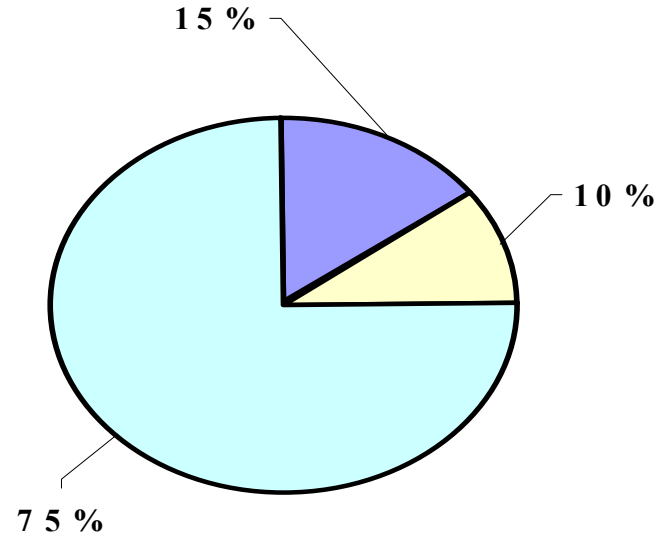
Source of Water



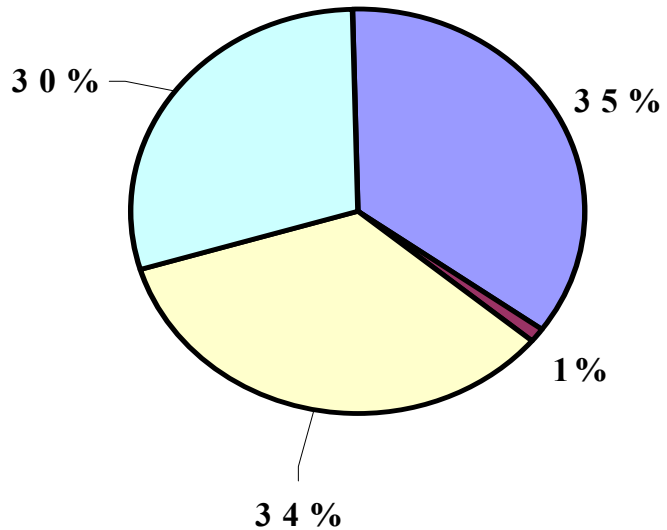
Colorado, Percent by Acres



Kansas, Percent of Acres

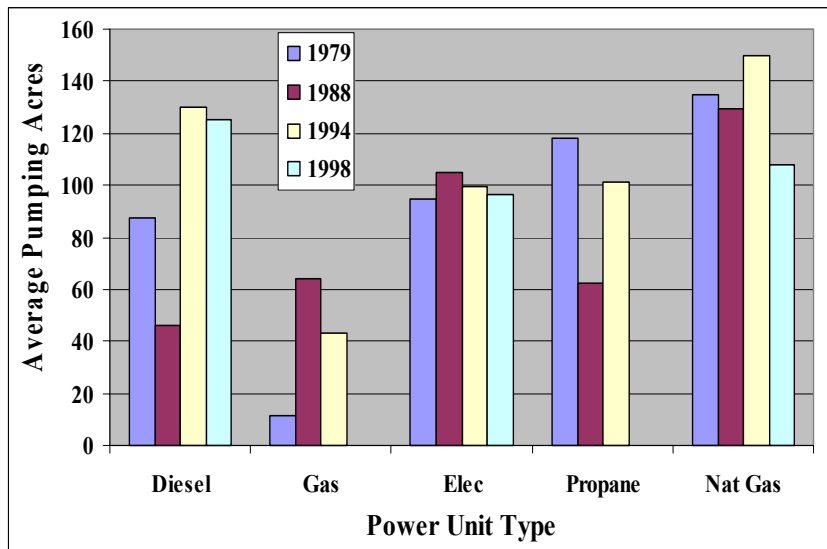


Texas, Percent by Acres

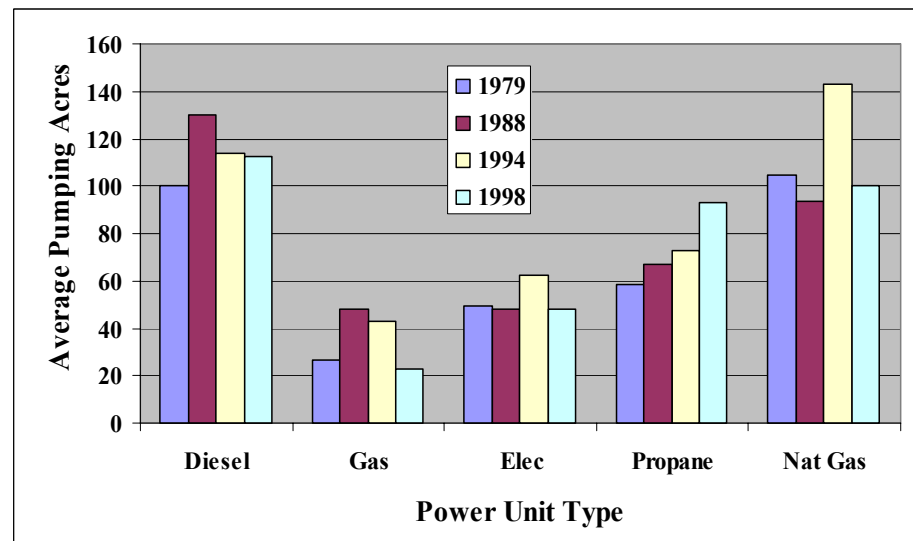


 Diesel  Gasoline  Electric  LP or Natural Gas

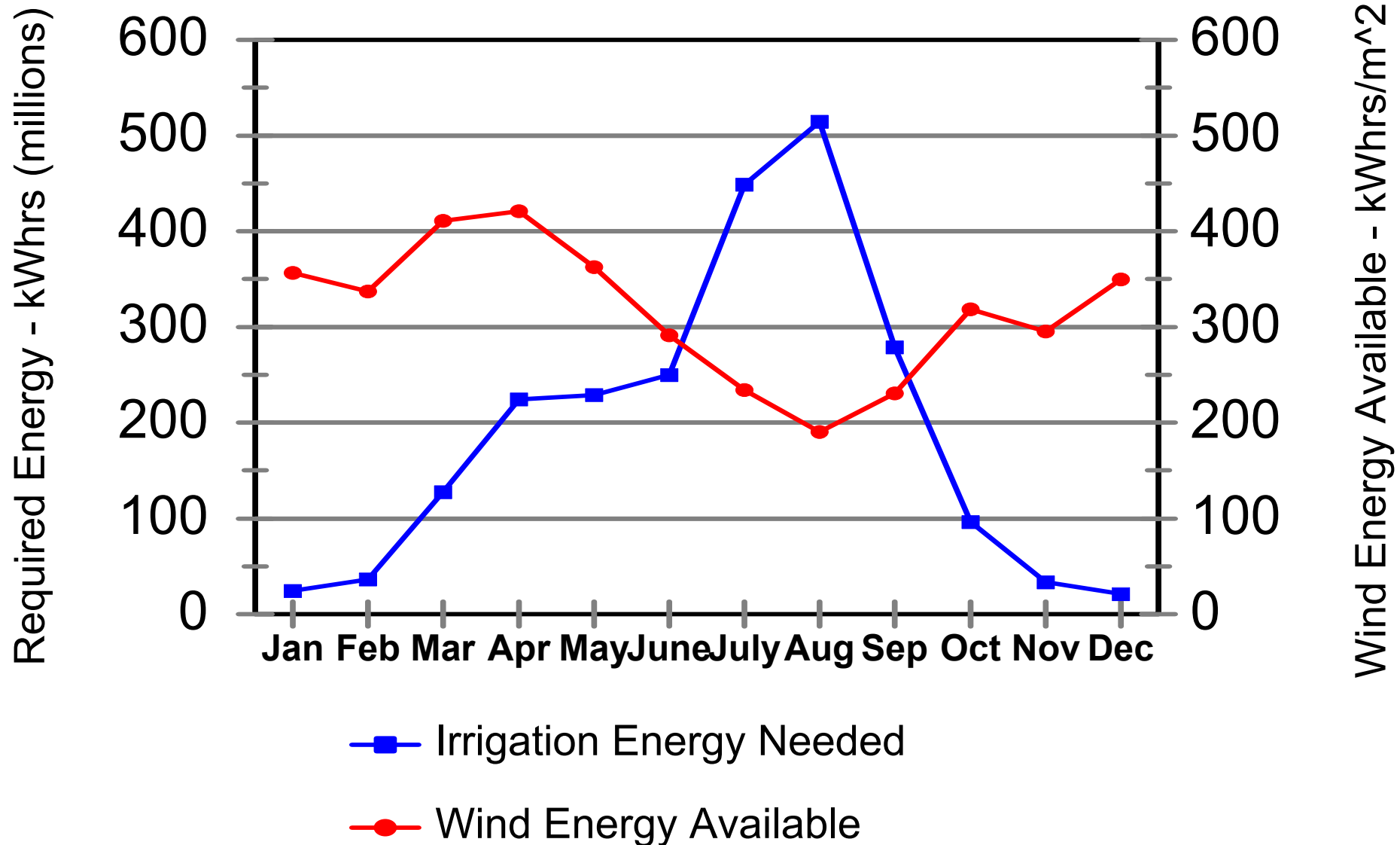
Colorado



Texas



Irrigation Energy Needed & Wind Energy Available (1997-2000)





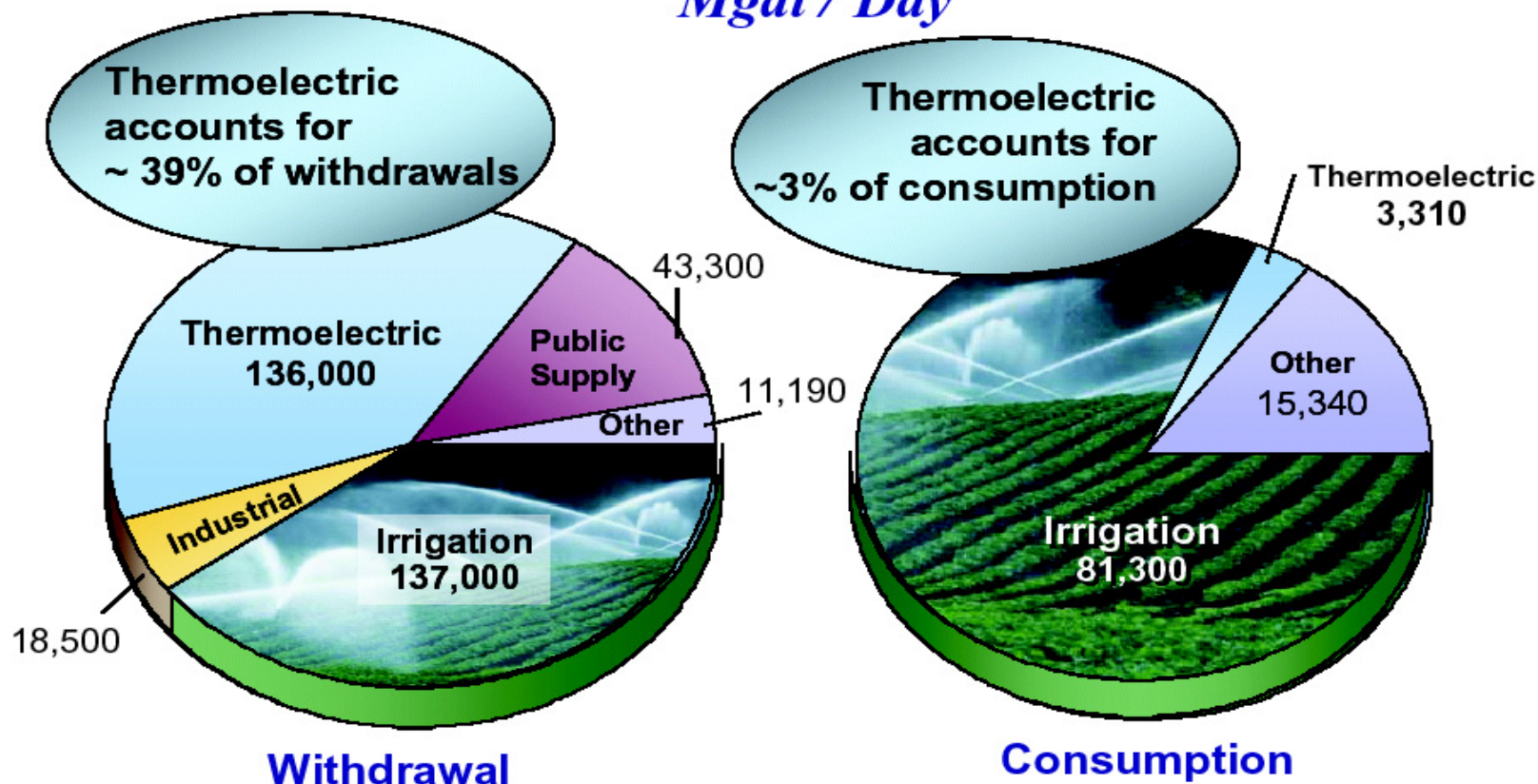
WESTERN RESOURCE
ADVOCATES

***Water/Electricity Use at
Fossil Fuel Power Plants***

Bart Miller, Water Program Director

Freshwater Withdrawals and Consumption

Mgal / Day

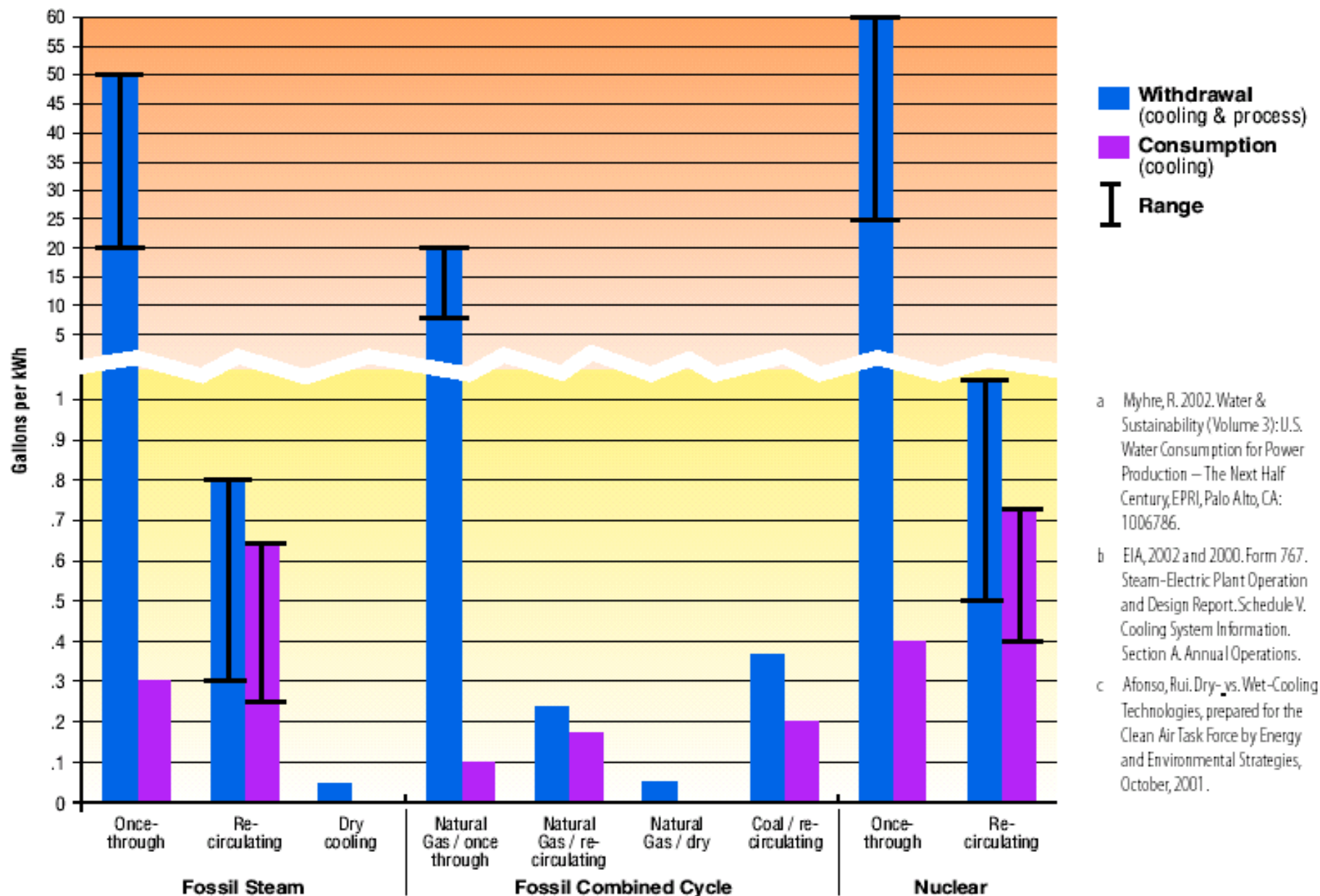


Ref.: "Estimated Use of Water in the United States in 1995," USGS Circular 1200, 1998
"Estimated Use of Water in the United States in 2000," USGS Circular 1268, March 2004

EPRI Environmental Sector Boston 2004

Thomas Feeley, III, "Responding to Emerging Power Plant-Water Issues – DOE/NETL's R&D Program"

Cooling Water Withdrawal and Consumption, by fuel and technology in gal/kWh^{a, b, c}



a Myhre, R. 2002. Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century, EPRI, Palo Alto, CA: 1006786.

b EIA, 2002 and 2000. Form 767. Steam-Electric Plant Operation and Design Report. Schedule V. Cooling System Information. Section A. Annual Operations.

c Afonso, Rui. Dry- vs. Wet-Cooling Technologies, prepared for the Clean Air Task Force by Energy and Environmental Strategies, October, 2001.

Thermoelectric Power Plants – Water Usage

In 2002, nationwide:

- Withdrawals of water at all thermoelectric power plants = 225 billion gallons/day
- = 252 million acre-feet
- ~ $\frac{3}{4}$ size of Lake Erie



Wind energy doesn't consume water



DESALINATION and WIND ENERGY

Johannes Theron

Abe Springer

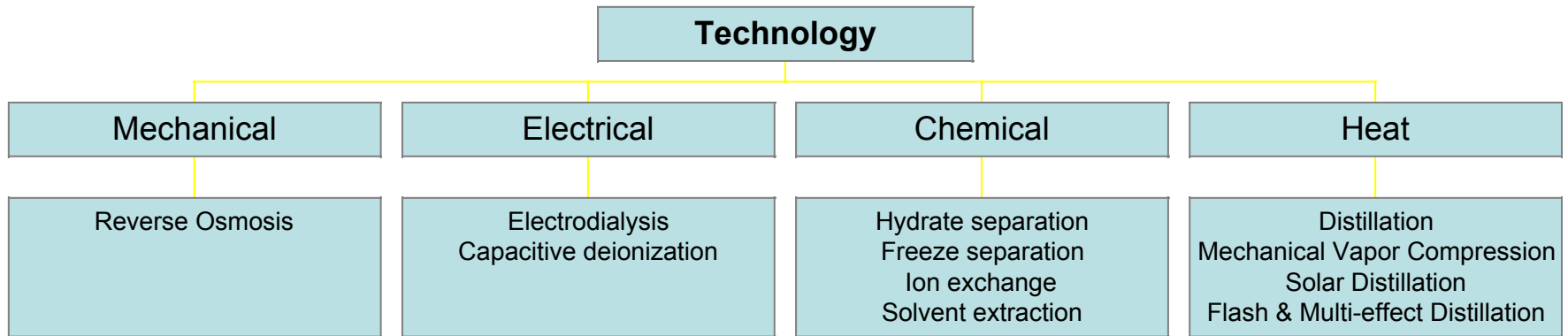
Amanda Ormond

Tom Acker

WATER OVERVIEW

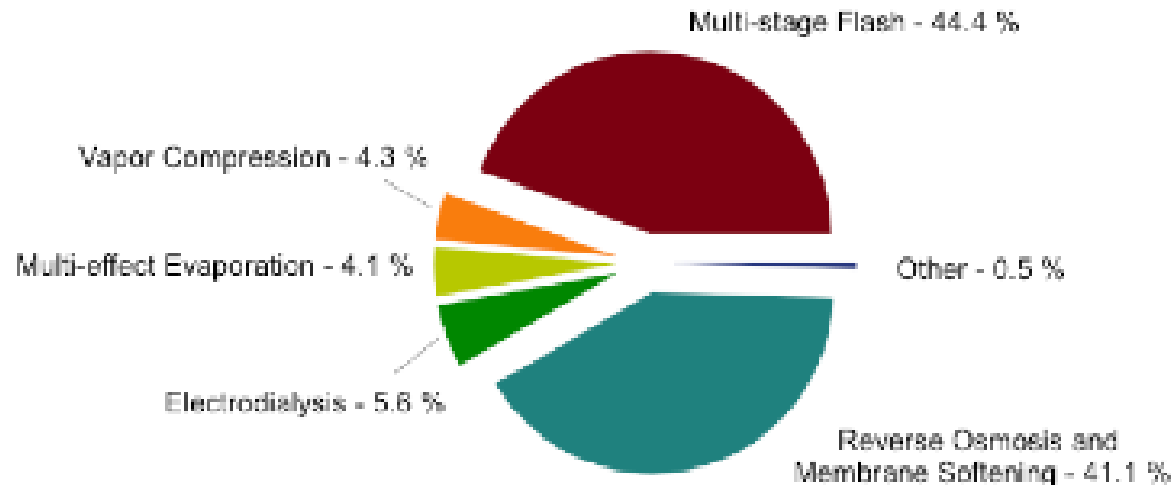
	World	US
Total water use (af/day)	8,700,000	1,250,000
Desalination capacity (af/day)	18,000	2,840
Specific use (af/person/year)	0.5	1.7

DESALINATION OVERVIEW



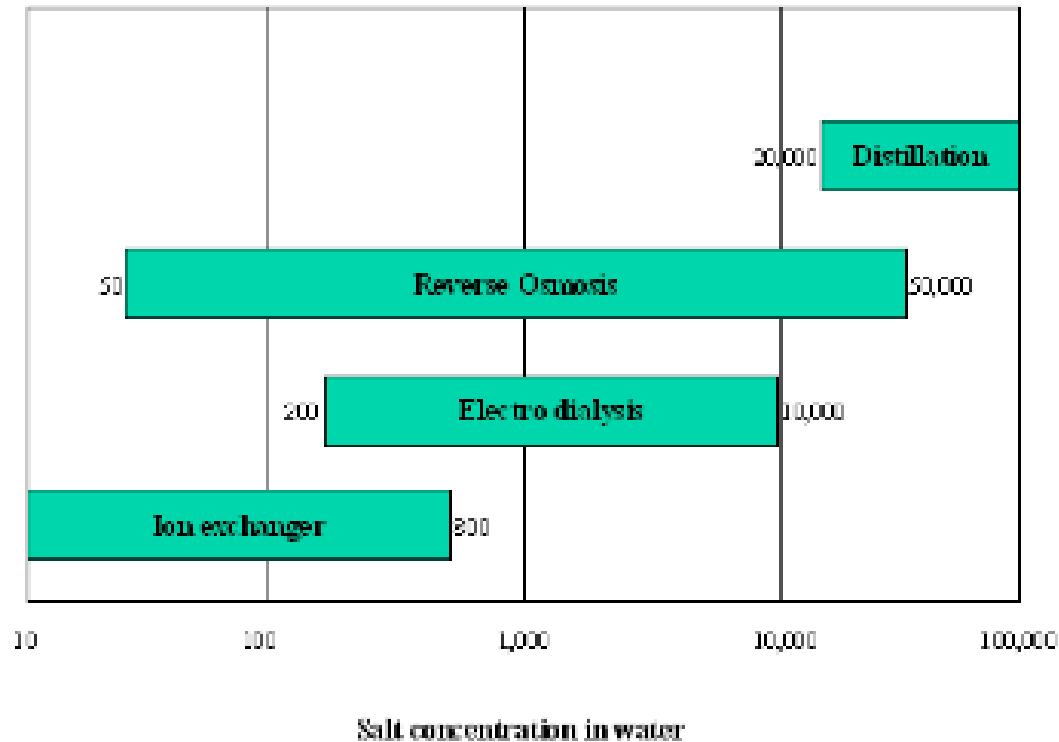
- Distillation practiced since ancient times
- ED since 1920s
- RO since 1950s
- Capacitive deionization not full-scale

INSTALLED CAPACITY



- Flash distillation & RO dominate
- MVC & ED minor players

APPLICATION DOMAINS



- Distillation & RO - seawater & brine
- ED & IX & RO - brackish water

GEOGRAPHIC DISTRIBUTION

World - 8,600 plants

Majority of facilities in Middle East (MSF)

US 20% of world plants

TX (100+ brackish plants) Sherman - 80af/day

FL (10+ plants) Tampa Bay - 77af/day??

CA (10+ plants) - 8.5 af/day (712af/day proposed)

WA, ID, MT, NC, NJ, HI, VA, CO, AZ

DESALINATION COSTS

- Cost is a function of saline content & plant size
- Electricity the major cost component (RO&ED)
- Fuel cost dominate for distillation processes
- Pretreatment cost vary with technology (RO~\$0.13/m³)
- Cost of brine disposal should be considered
- Tampa Bay - 14MW installed (77 af/day desal)

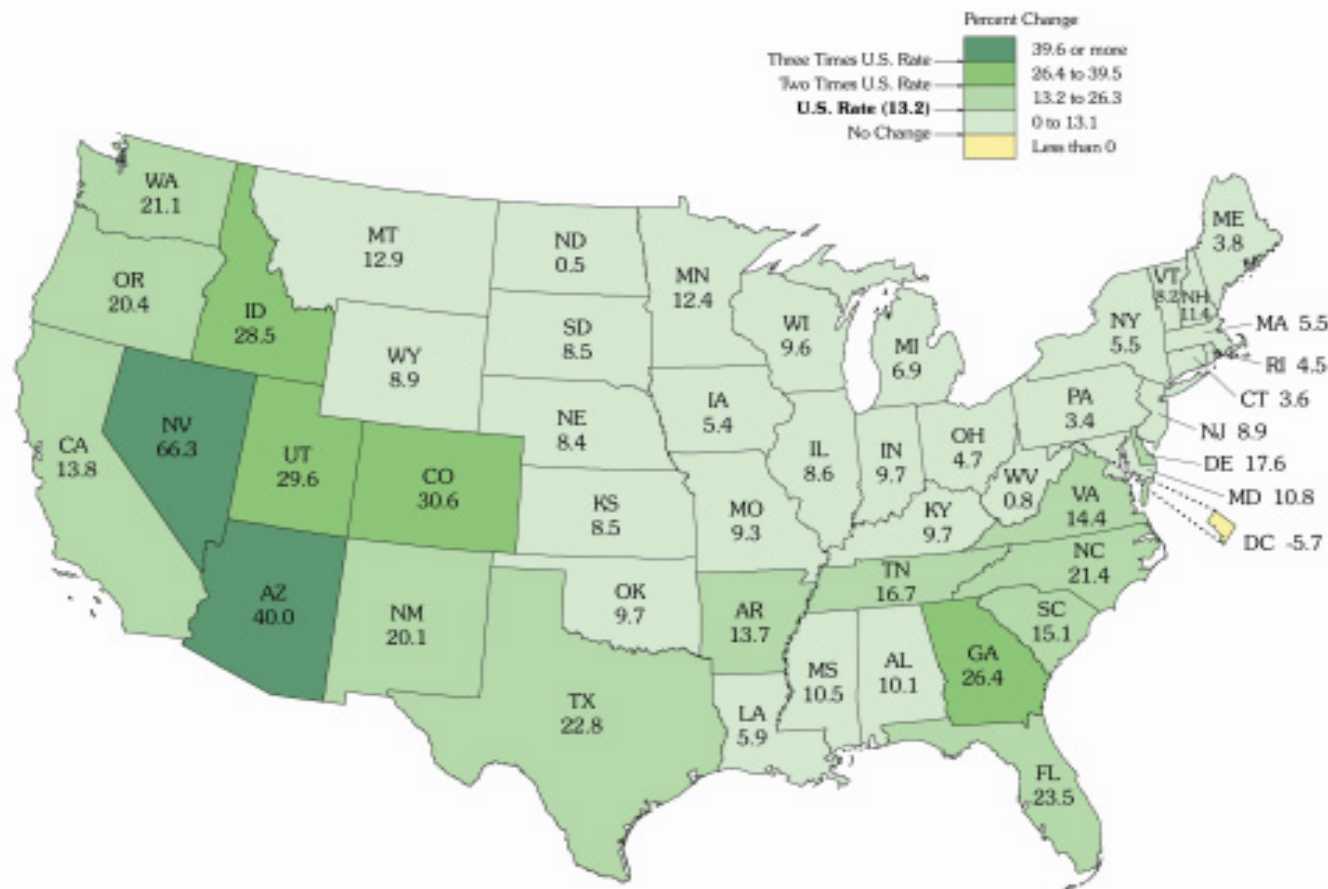
The Energy-Water Nexus and the Municipal Sector

Robert Wilkinson, Ph.D.

Director, Water Policy Program
Bren School of Environmental Science and Management
University of California, Santa Barbara

Demographic Changes: Population Has Grown Fastest in the West, Particularly in the “Public Land States”

Percent Change in Resident Population for the 50 States and the District of Columbia: 1990 to 2000

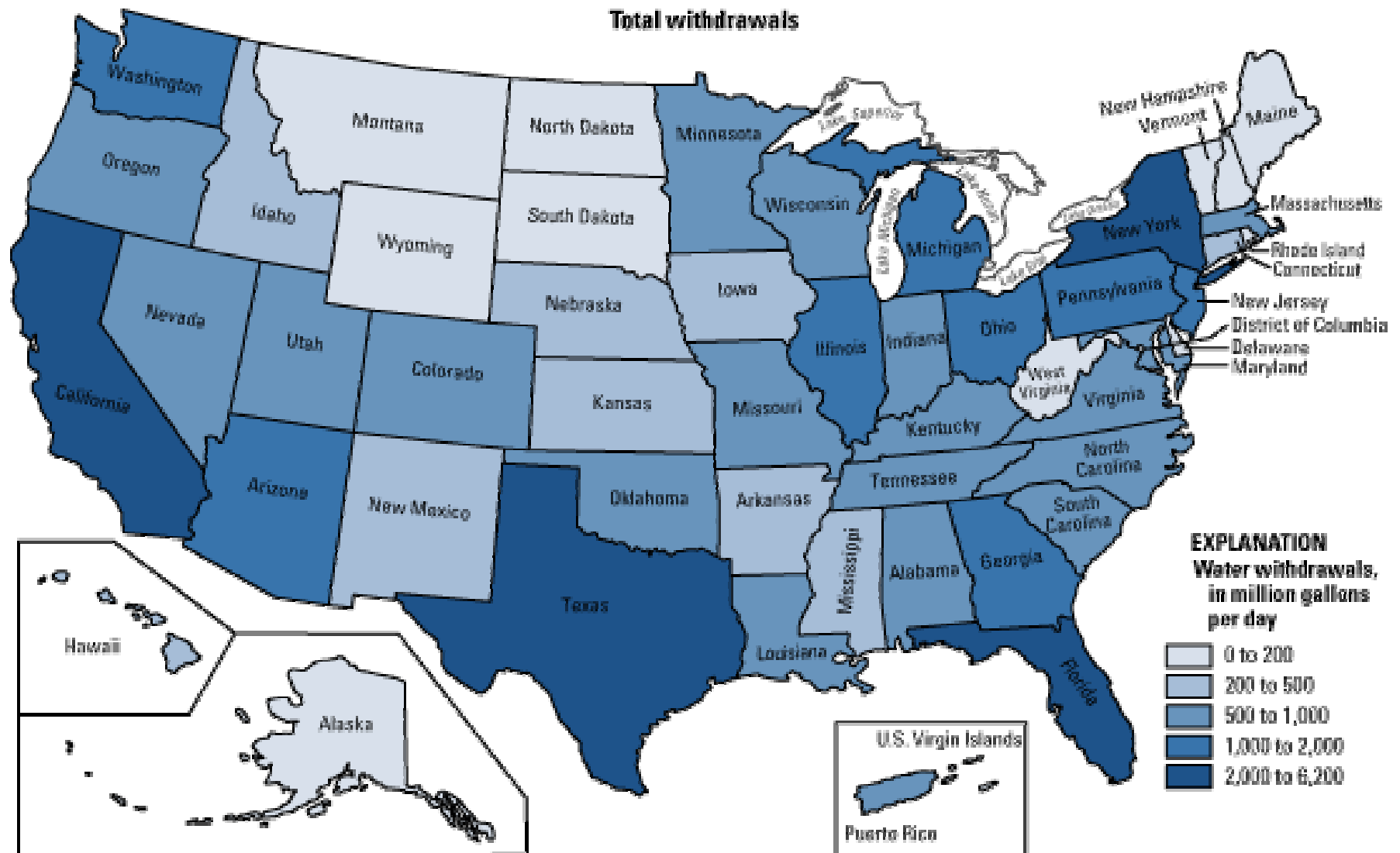


- Darker areas denote faster growth rates.

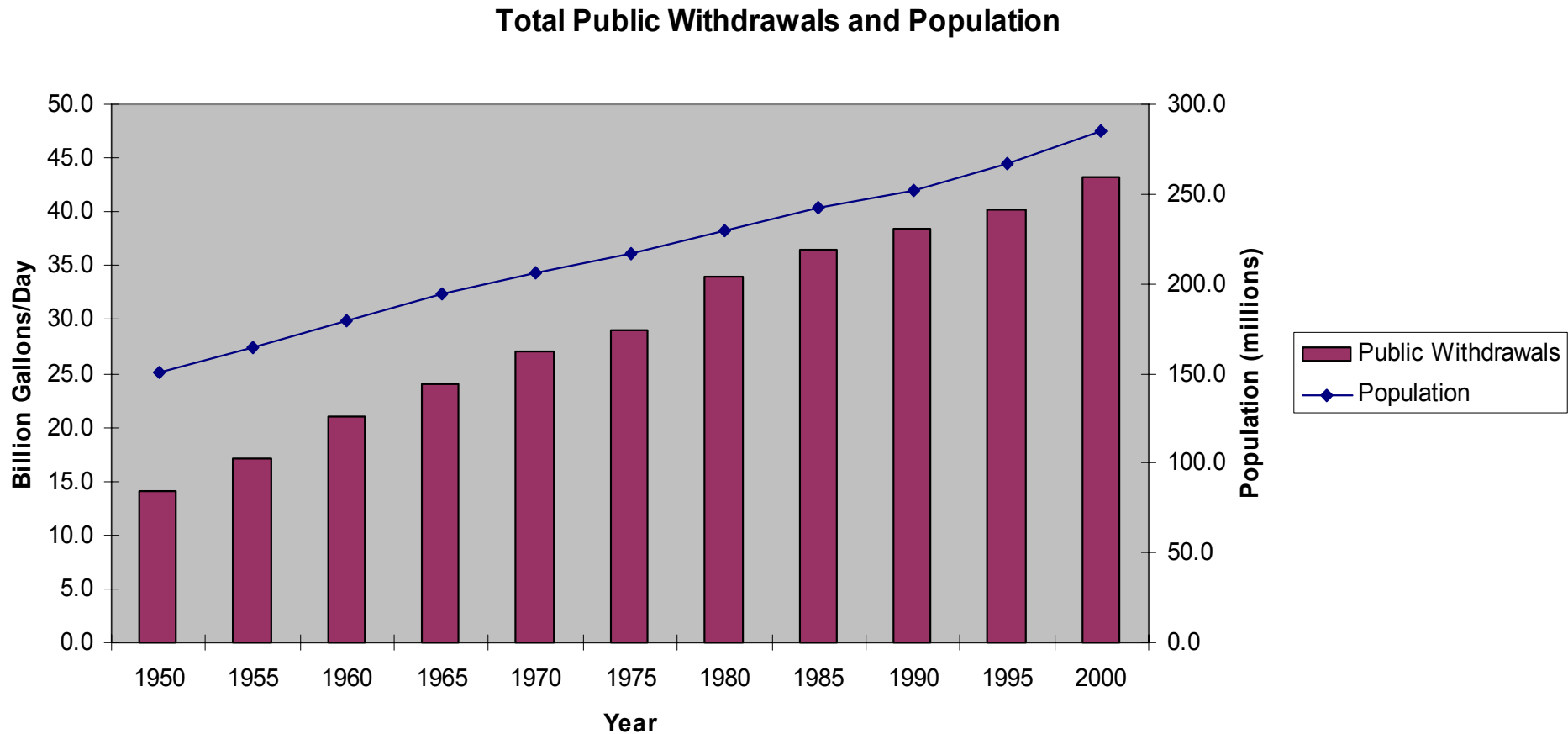
- Nevada (66%) and Arizona (40%) lead the nation.

- Intermountain states average about 30%.

Public Supply Withdrawals, 2000



Total Public Withdrawals and Population



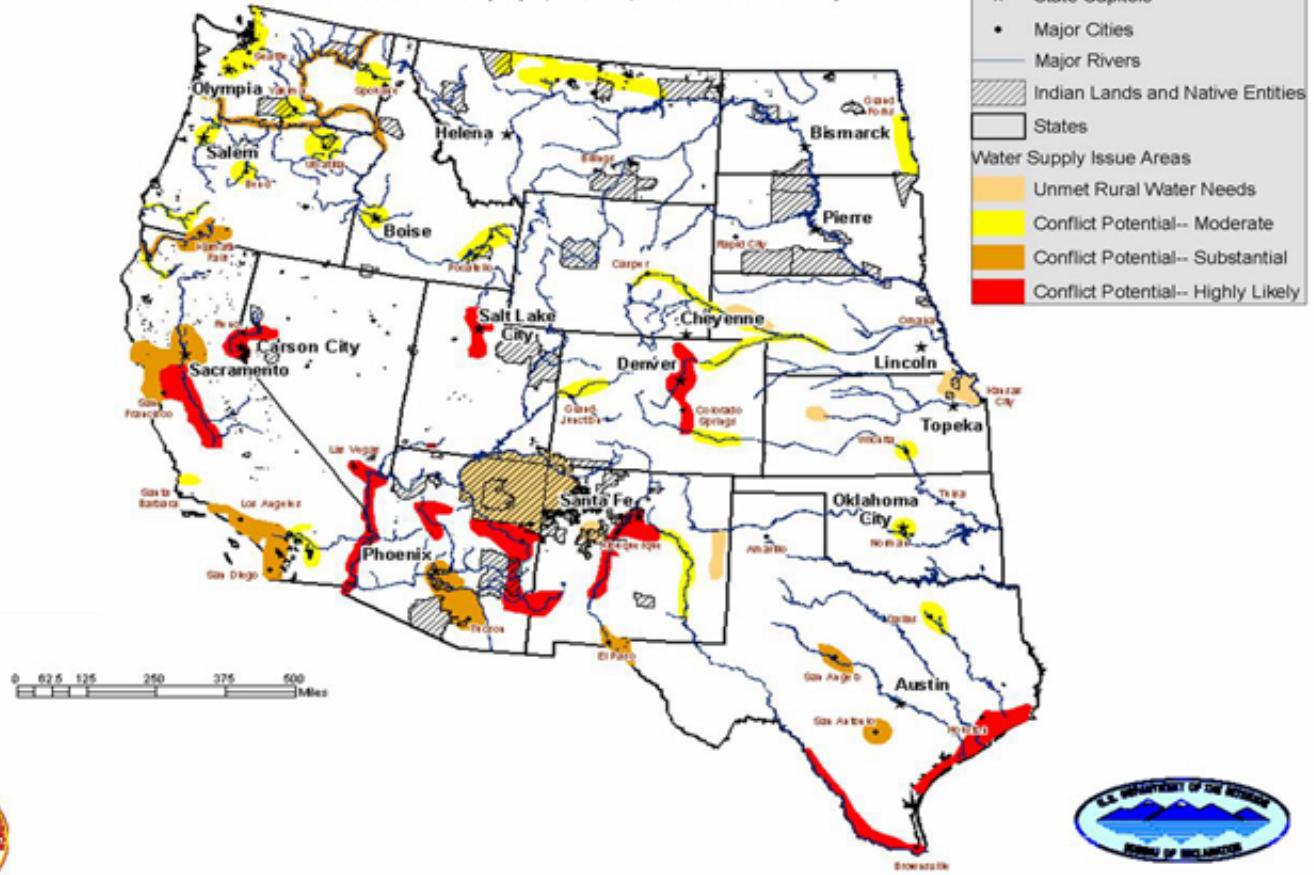
Source: **USGS Circular 1268**, released March 2004 and revised April and May 2004

<http://water.usgs.gov/pubs/circ/2004/circ1268/htdocs/table14.html>

Hot Spots

Potential Water Supply Crises by 2025

(Areas where existing supplies are not adequate to meet water demands for people, for farms, and for the environment)




May 2003

Drought Impacts

- Reduced water for thermal power production
- Increased demand by both urban and agricultural users
- Increased pumping requirements to meet demand (both surface and groundwater)
- Reduced hydropower production

Opportunities for Wind-Water Processing

- 
- Wind-Hydro Integration
 - Desalination
 - Irrigation
 - Municipal Waste Water Treatment
 - Coal Bed Methane Extraction Water Treatment
 - Stock Watering
 - Next Step:
 - Strategic Options Development
 - Collaboration with Desal. & Irrigation Institutions
 - Coordination with InterLab Wind-Water Group

Humanity's Top Ten Problems for next 50 years

1. ENERGY
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION



2003	6.3	Billion People
2050	9-10	Billion People